nuclear
weapons
journal

January/February 2003

Niobium

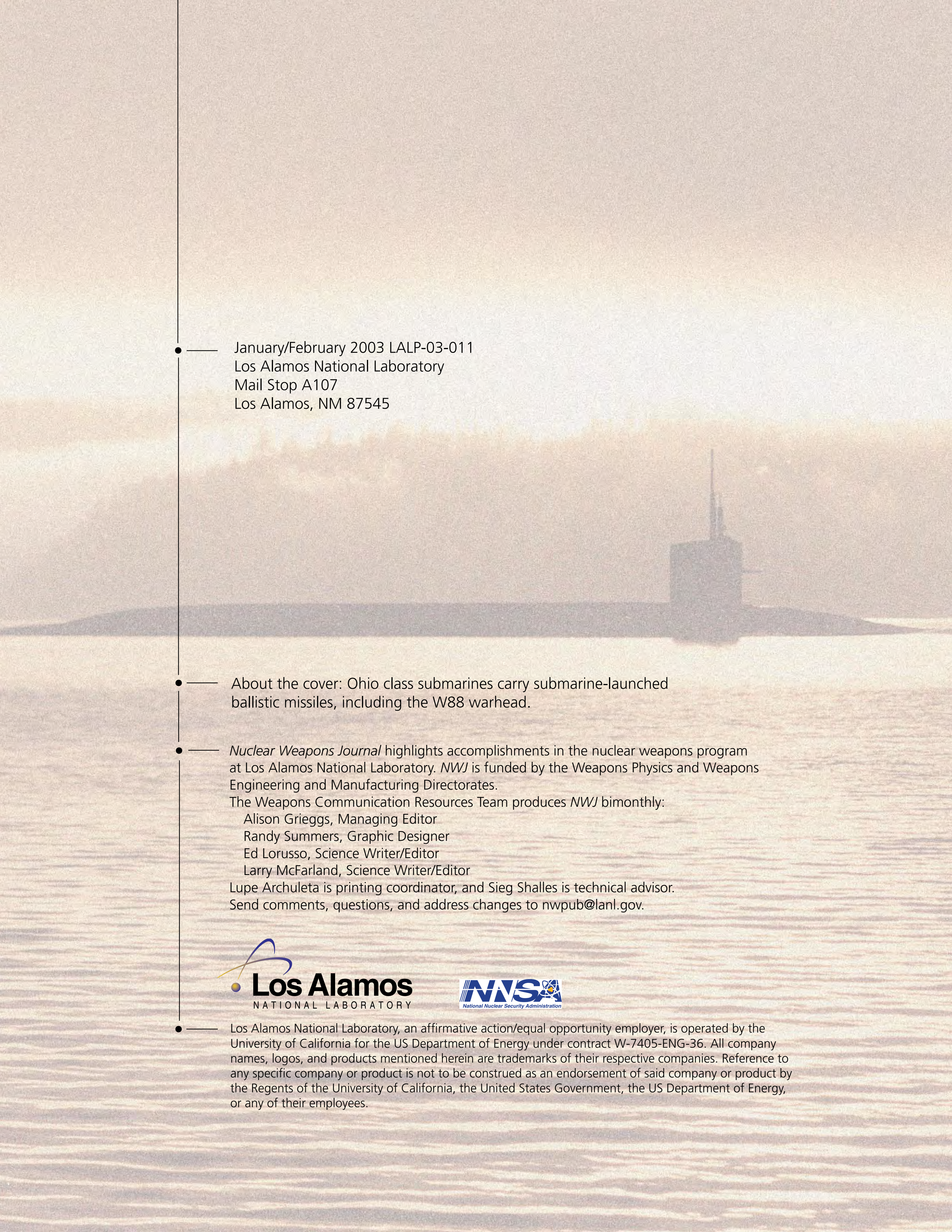
Hercules

DARHT on Target

Rocco

Fragment Impact

Weapons Science and Engineering at Los Alamos National Laboratory



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About the cover: Ohio class submarines carry submarine-launched ballistic missiles, including the W88 warhead.

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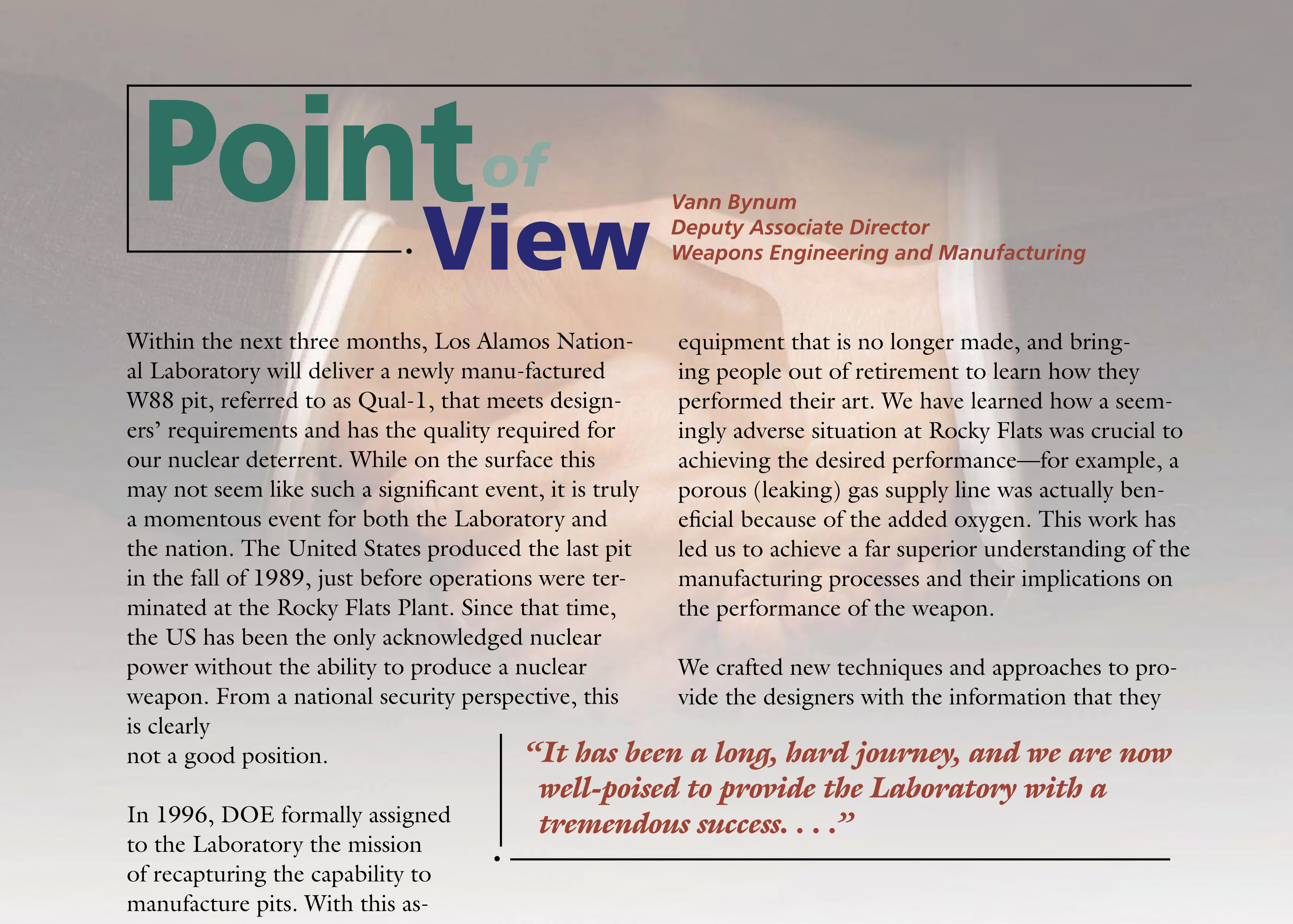


Point of View

Vann Bynum
Deputy Associate Director
Weapons Engineering and Manufacturing

Within the next three months, Los Alamos National Laboratory will deliver a newly manu-factured W88 pit, referred to as Qual-1, that meets designers' requirements and has the quality required for our nuclear deterrent. While on the surface this may not seem like such a significant event, it is truly a momentous event for both the Laboratory and the nation. The United States produced the last pit in the fall of 1989, just before operations were terminated at the Rocky Flats Plant. Since that time, the US has been the only acknowledged nuclear power without the ability to produce a nuclear weapon. From a national security perspective, this is clearly not a good position.

In 1996, DOE formally assigned to the Laboratory the mission of recapturing the capability to manufacture pits. With this assignment coming back home (remember that Los Alamos was the sole producer of pits until 1952), a team was pulled together from across the Laboratory to put into place the technologies, equipment, and systems necessary to demonstrate the ability to manufacture War Reserve pits. What started as a relatively small project has grown substantially as the full scope of manufacturing pits of a quality commensurate with the stockpile requirements was realized. The growth in the project and its importance was accompanied by increasing interest at various levels, culminating in required quarterly reports to Congress.

As we have progressed toward meeting this critical milestone, many technical challenges have pre-sented themselves, and our staff has consistently risen to the challenge—performing extensive detective work to understand both the art and the science of fabricating modern pit designs, reverse-engineering equipment that is no longer made, and bringing people out of retirement to learn how they performed their art. We have learned how a seemingly adverse situation at Rocky Flats was crucial to achieving the desired performance—for example, a porous (leaking) gas supply line was actually beneficial because of the added oxygen. This work has led us to achieve a far superior understanding of the manufacturing processes and their implications on the performance of the weapon.

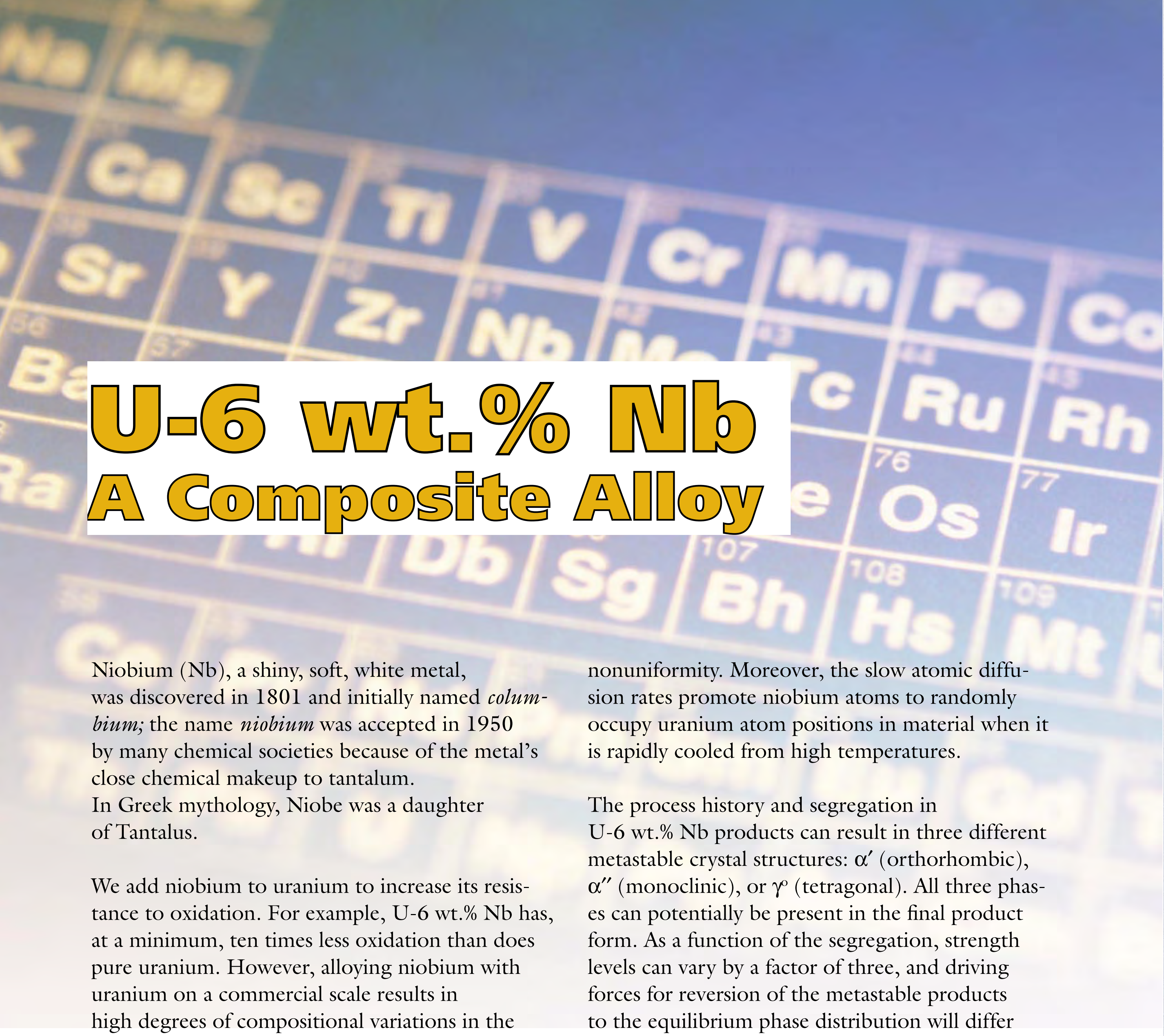
We crafted new techniques and approaches to provide the designers with the information that they require to certify warheads with newly manufactured pits for use in the stockpile. While making a pit that meets the exceptionally high quality standards required for War Reserve use presents enough of a challenge, we have had to make pits with carefully controlled defects to demonstrate clearly our ability to detect those defects if they should arise during the normal course of production. Producing these controlled defects challenged our techniques and our creativity, while actually producing some fun!

> ***"It has been a long, hard journey, and we are now well-poised to provide the Laboratory with a tremendous success. . . ."***

When faced with how to make uniform voids within a cast and machined part, our staff determined that we could simulate voids by the inclusion of sapphires, which are available in precise sizes and are relatively transparent to x-rays. This type of creativity has been crucial to the project's success.

We have developed processes to adapt what was done at Rocky Flats but under the constraints

Continued on page 16



U-6 wt.% Nb
A Composite Alloy

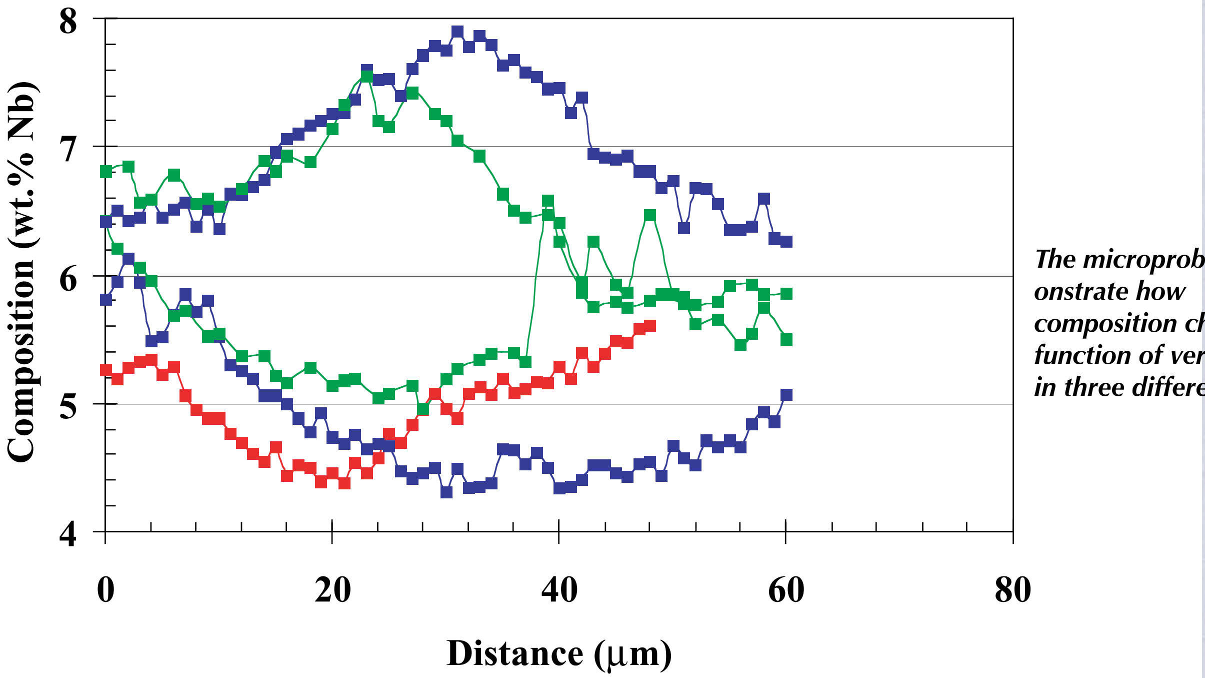
Niobium (Nb), a shiny, soft, white metal, was discovered in 1801 and initially named *columbium;* the name *niobium* was accepted in 1950 by many chemical societies because of the metal's close chemical makeup to tantalum.
In Greek mythology, Niobe was a daughter of Tantalus.

We add niobium to uranium to increase its resistance to oxidation. For example, U-6 wt.% Nb has, at a minimum, ten times less oxidation than does pure uranium. However, alloying niobium with uranium on a commercial scale results in high degrees of compositional variations in the material. Density and melting temperature differences between uranium and niobium cause a cast ingot to exhibit compositional segregation levels that vary from the desired nominal composition.

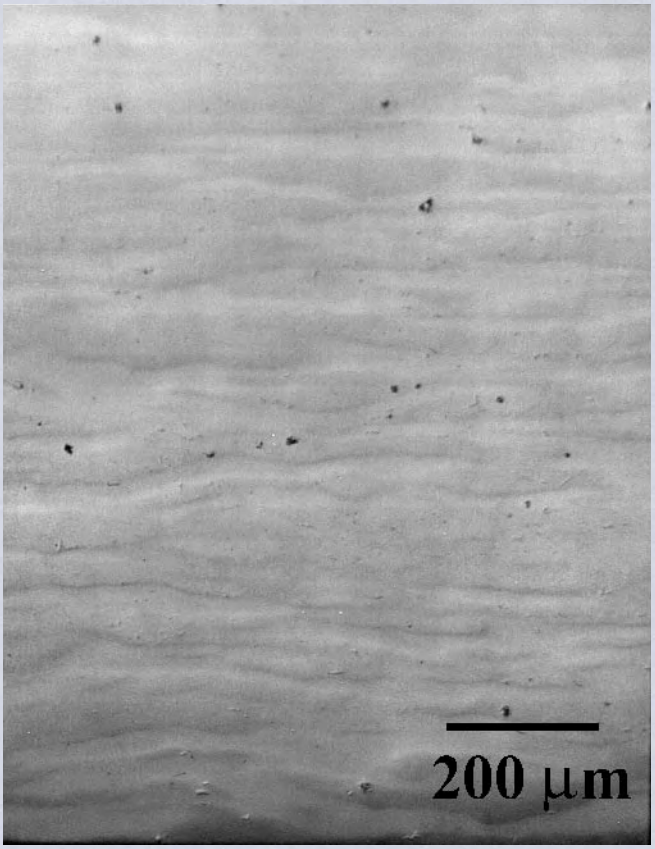
The compositional banding persists in the plate product, even though the material is heat treated and rapidly cooled to room temperature. The sluggish diffusion kinetics of niobium in uranium prevents reasonable homogenization times and temperatures that would eliminate the chemical nonuniformity. Moreover, the slow atomic diffusion rates promote niobium atoms to randomly occupy uranium atom positions in material when it is rapidly cooled from high temperatures.

The process history and segregation in U-6 wt.% Nb products can result in three different metastable crystal structures: α' (orthorhombic), α'' (monoclinic), or γ^o (tetragonal). All three phases can potentially be present in the final product form. As a function of the segregation, strength levels can vary by a factor of three, and driving forces for reversion of the metastable products to the equilibrium phase distribution will differ as the material ages at ambient temperature. The uranium-niobium alloy should be considered as a composite material with internally unique aging characteristics that can vary, depending on the location within the final product.

To address the complex nature of phase stability in uranium-niobium alloys, we conducted experiments to understand the aging behavior of the material. We performed accelerated aging experiments within the metastable crystal structure stability limits (<100 °C); and results suggest that



The microprobe scans demonstrate how composition changes as a function of vertical distance in three different locations.



Compositional banding in U-6 wt.% Nb plate. The flow lines in the micrograph illustrate chemical nonuniformity in the sheet product. Carbide inclusions are also evident in the micrograph as dark dots.

U-6 wt.% Nb alloys start to age immediately after quenching, with the mechanical strength increasing about 10% within a week (up to a maximum change of about 25%).

We found that the main aging responses in the material are the appearance of γ^o (the metastable phase at the highest niobium concentrations and lowest temperature phase stability) and the potential for niobium atom clustering. We hypothesize that the appearance of the γ^o phase occurs because of a stress relaxation in com-positionally rich areas of the banded composite commercial material. The solute clustering can be linked to a fine-scale chemical segregation as the system attempts to lower its free energy to its equilibrium configuration. We are focusing on characterizing material thermophysical properties as a function of composition in controlled starting material.

The uranium-niobium alloy is important to stockpile stewardship because it helps slow uranium oxidation and thereby lengthens the life of uranium in the stockpile. ✸
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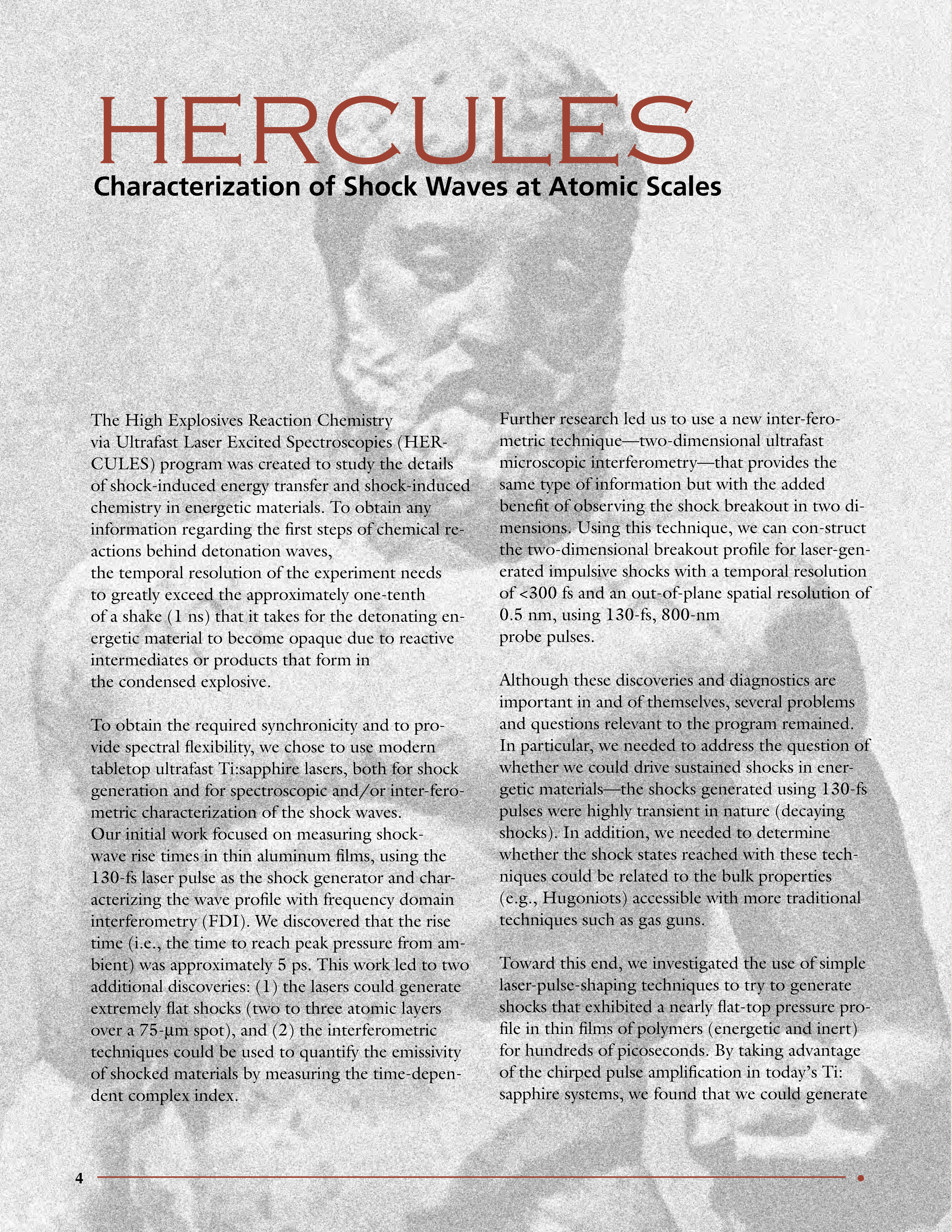

HERCULES

Characterization of Shock Waves at Atomic Scales

The High Explosives Reaction Chemistry via Ultrafast Laser Excited Spectroscopies (HERCULES) program was created to study the details of shock-induced energy transfer and shock-induced chemistry in energetic materials. To obtain any information regarding the first steps of chemical reactions behind detonation waves, the temporal resolution of the experiment needs to greatly exceed the approximately one-tenth of a shake (1 ns) that it takes for the detonating energetic material to become opaque due to reactive intermediates or products that form in the condensed explosive.

To obtain the required synchronicity and to provide spectral flexibility, we chose to use modern tabletop ultrafast Ti:sapphire lasers, both for shock generation and for spectroscopic and/or inter-ferometric characterization of the shock waves. Our initial work focused on measuring shock-wave rise times in thin aluminum films, using the 130-fs laser pulse as the shock generator and characterizing the wave profile with frequency domain interferometry (FDI). We discovered that the rise time (i.e., the time to reach peak pressure from ambient) was approximately 5 ps. This work led to two additional discoveries: (1) the lasers could generate extremely flat shocks (two to three atomic layers over a 75-µm spot), and (2) the interferometric techniques could be used to quantify the emissivity of shocked materials by measuring the time-dependent complex index.

Further research led us to use a new inter-ferometric technique—two-dimensional ultrafast microscopic interferometry—that provides the same type of information but with the added benefit of observing the shock breakout in two dimensions. Using this technique, we can con-struct the two-dimensional breakout profile for laser-generated impulsive shocks with a temporal resolution of <300 fs and an out-of-plane spatial resolution of 0.5 nm, using 130-fs, 800-nm probe pulses.

Although these discoveries and diagnostics are important in and of themselves, several problems and questions relevant to the program remained. In particular, we needed to address the question of whether we could drive sustained shocks in energetic materials—the shocks generated using 130-fs pulses were highly transient in nature (decaying shocks). In addition, we needed to determine whether the shock states reached with these techniques could be related to the bulk properties (e.g., Hugoniots) accessible with more traditional techniques such as gas guns.

Toward this end, we investigated the use of simple laser-pulse-shaping techniques to try to generate shocks that exhibited a nearly flat-top pressure profile in thin films of polymers (energetic and inert) for hundreds of picoseconds. By taking advantage of the chirped pulse amplification in today's Ti: sapphire systems, we found that we could generate a laser-pulse profile that had a 10-ps rise, followed by a slowly varying amplitude, to yield sustained shocks on the order of 200 ps in duration.

Finally, we examined the shock wave propagation in the inert material PMMA (polymethylmethacrylate) with ultrafast spatial interferometry. The inter-ferometric measurements of the shock dynamics in this transparent thin film exhibit features caused by both surface motion and the interference of multiple reflections off the moving shock-wave interface. The interference effects are strong perturbations on the measured phase shifts and therefore did not permit independent measurement of surface motion. However, calculations of the time-dependent phase shift that include reflective surface motion, shock-wave transit through the transparent thin film, and thin-film interference effects were shown to match experimental mea-surements in 625-nm-thick films of PMMA shocked to 19 GPa.

By acquiring interferometric data at two angles of incidence and two polarizations, we were able to uniquely determine the PMMA shocked refractive index, shock speed, and particle velocity. The interferometric results as a function of shock strength, 2–20 GPa, indicate that the submicrometer PMMA films have the same material response to shock loading (Hugoniot) as do macroscopic samples.

We have answered many of the initial questions regarding the use of laser-generated shocks and have reported our experimental results in pro-fessional journals. We are presently conducting shock studies of the energetic polymers nitro-cellulose, polyvinyl nitrate, and glycidal azide using a combination of spatial interferometry, mid-infrared vibrational spectroscopy, and UV-Vis electronic spectroscopy to try to observe shock-induced chemistry in real time. ✹
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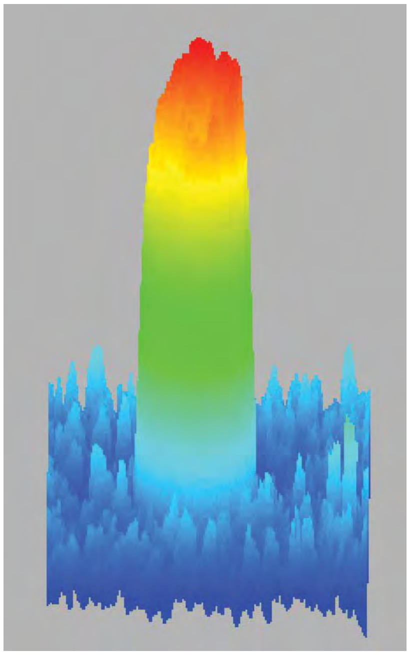
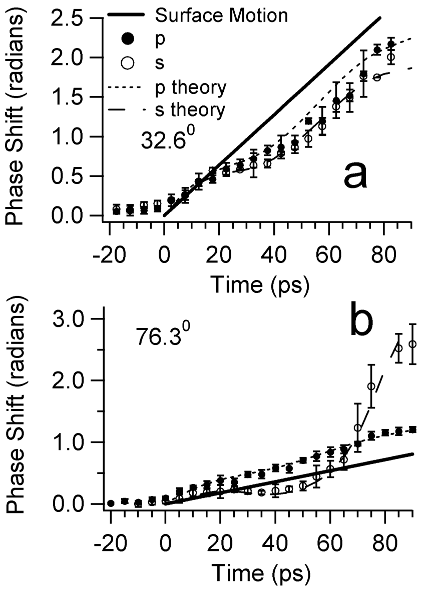
Image of an aluminum surface recorded ~10 ps after shock-wave arrival, using ultrafast spatial interferometry. The surface has moved approximately 6 nm in the vertical direction (the scale is ~200 μm x 200 μm in the horizontal plane). A slight tilt (~1 nm) of the shock wave is evident in the image.





A plot of measured and calculated phase shifts for a 625-nm-thick PMMA film on aluminum during shock, obtained by using ultrafast spatial interferometry. The lines are theoretical predictions for an aluminum shock pressure of 19 GPa. The solid line is surface motion only; the dotted (p-polarization) and dashed (s-polarization) lines are calculated to include thin-film interference effects. The experimental points are for (a) 32.6-degree angle of incidence and (b) 76.3-degree angle of incidence.

DARHT ON TARGET

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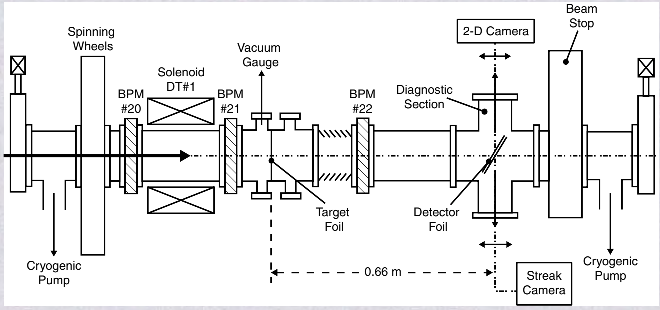
DARHT ON TAR-

The Dual-Axis Radiographic Hydrodynamic Test (DARHT) facility consists of two large x-ray machines set at 90 degrees to each other. The first axis, running since the spring of 1999, delivers a single pulse of energetic electrons onto a metal target to produce a burst of x-rays. When the second axis comes on line in the summer of 2004, DARHT will produce time-resolved, 2-view radiographs of simulated weapon primaries at the time of implosion; the first and second axes will provide first-ever, 3-D radiographic implosion data.

The second axis will deliver a train of four, tightly focused, intense electron-beam pulses to an x-ray converter target in 2 µs. A major concern is that beam-ionized impurity molecules, originating from the target surface, will be accelerated and trapped by the beam's negative potential. This time-dependent column of positive charge can readily neutralize a significant fraction of electron-beam space charge, changing the focal length and degrading the radiographic spot size. To assess the importance of this phenomenon, Hal Davis, Dave Moir, and Christophe Vermare performed experiments using the single-pulse, first-axis beam (19.8 MeV, 1.7 kA, 60 ns), and Tom Hughes (Mission Research Corporation) modeled the experiments with a particle-in-cell code.

The beam is focused onto and propagates through a thin target foil to an optical diagnostic section (see the accompanying experimental setup schematic). The initial current density impinging on this target surface is varied over three orders of magnitude (0.5–500 A/mm^2) by adjusting an upstream focusing magnet. The time-dependent behavior of the beam radial profile is observed downstream at a detector foil. This "two-foil" technique is an improvement over the previous single-target experiments because the distance between the target and the detector foils amplifies the effect of ions on beam disruption (thus reducing diagnostic resolution requirements) and provides two surfaces for ion flow. With no ion emission from the target foil, the beam profile is expected to be time independent.

The effect on beam behavior as the beam-current density is increased on an aluminum target foil is shown in the accompanying streak-picture graphics. Streak pictures on the left (beam current density along the vertical and time along the horizontal axes) from the experiment are compared with simulated streak pictures from the computer calculations for the target foil. The figures on the right show the same results at the diagnostic foil. There are three cases, (a)–(c), with progressively decreasing beam-spot size (increasing current density) at the target. The calculations assume that ions are produced at the target foil when the target foil temperature increases by 400 °C due to foil heating by the beam. This is the temperature at which thermal desorption of impurity neutrals on the foil is expected to occur on a time scale shorter than the beam pulse duration.



Experimental setup of the DARHT first axis, designed to investigate electron-beam disruption by positive charges originating from the target foil.

The agreement between the experiments and calculations is very good. Case (a) shows that for a relatively large spot size on the target (i.e., low current density and therefore a temperature rise of less than 400 °C), the beam profile at the diag-nostic foil is time independent, as expected for no ion emission. Cases (b) and (c) show that when the spot size is reduced at the target foil, beam disruption (i.e., a sudden increase in the beam radius) observed at the diagnostic foil occurs part- way through the pulse (i.e., when desorption of impurity molecules from the target foil occurs). The disruption time decreases as the spot size is reduced on the target foil as expected because heating of the target foil is faster. Similar behavior was found for all the target materials tested, from carbon to tantalum.

The data and the modeling suggest that for many of the materials, the dominant desorbed species is water, which is ionized by the beam into a number of different components (H^+, H_2O^+, OH^+, and O^+). The ion current is carried by a combination of these species. Recent experiments to measure the composition and quantity of the neutral species desorbed by the beam, using a fast ionization gauge and a quadrupole mass spectrometer, have shown that for aluminum and graphite targets water vapor is in fact the dominant desorbed species with up to one monolayer of gas being released. Measurements using an ion spectrometer have just started and will allow for unambiguous identification of the ion species trapped by the beam. These results are being folded into DARHT second-axis target designs. ✹
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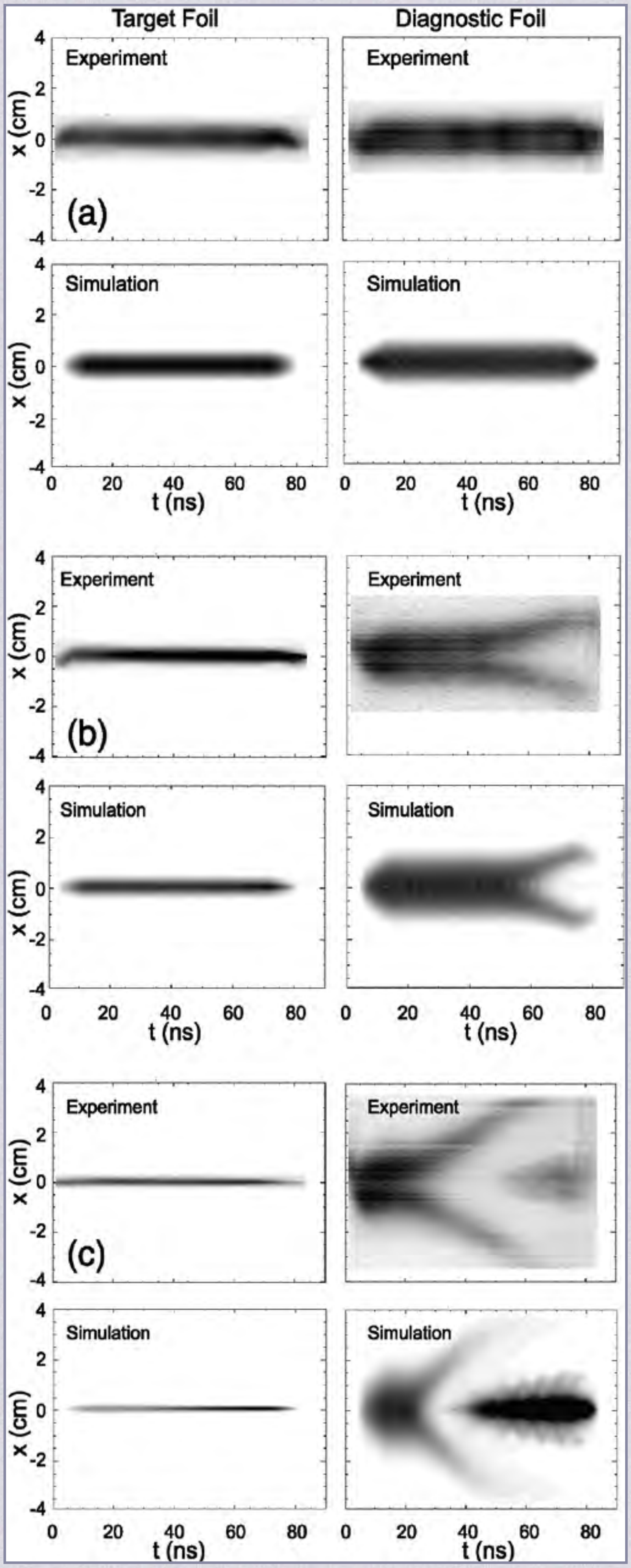

Actual and simulated pictures showing the effects of positive ions in causing electron-beam disruption. Disruption becomes more severe as the spot size on the target foil decreases. Agreement between experiments and calculations is very good.

Rocco

Subcritical Experiment

Rocco, the third subcritical experiment (SCE) in the Stallion series, was successfully executed September 26, 2002, in the U1a complex at the Nevada Test Site (NTS). Rocco followed Mario, successfully executed August 29, 2002, and both shots followed the UK's Vito/Etna SCE, executed February 14, 2002. The Rocco diagnostics and package design were identical to those of the Mario event, but Rocco provided physical-properties data for cast plutonium at conditions approaching those found in nuclear weapons to complement the data on wrought plutonium obtained from the Mario experiment.

Like Vito/Etna and Mario, Rocco used the racklet concept for deployment and execution as described in the Vito/Etna article (*Weapons Insider*, January–June 2002, pp. 1–2). The racklet held the experimental package, the diagnostics, vacuum support, and environmental and containment monitors and was stemmed in an emplacement hole augured into the invert (tunnel floor).

The Mario and Rocco SCEs were essentially identical. Both experiments were designed to measure the early-time hydrodynamic behavior of a layered assembly mockup of a primary. However, the goal was to compare different materials (Rocky Flats wrought and Los Alamos cast, respectively) in the same geometry subjected to weapons-relevant pressure magnitudes and histories. These experiments address mix physics to be used in computer-simulation codes that model the nuclear explosion process.

Data were returned on all channels and were typically of high quality. The data from Mario and Rocco are important both for their significance to the subcritical program and for execution of the Armando SCE, the fourth experiment in the Stallion series and scheduled for September 2003. Of principal interest on Mario and Rocco are the possible generation and dynamic development of spall. Armando will attempt to x-ray identical experimental packages to image and measure the separation of the spall layers.

To facilitate comparison of the behavior of wrought and cast plutonium, Rocco used the same diagnostic suite as Mario. Diagnostics included line velocity interferometer system for any reflector (VISAR), point VISAR, Asay foil, Asay windows, piezoelectric probes, optical pins, and infrared pyrometry. The performance of high explosives (HE) is measured by electrical pins and microwave interferometry strips that are integrated into flat Mylar strips sandwiched between the HE layers. The diagnostics is described in more detail in the Mario article (*Weapons Insider*, September/October 2002, pp. 2–3).

The Asay window diagnostic was jointly developed by groups in LANL's P and DX Divisions and at SNL. A number of small HE-driven experiments were fired in firing chambers and at the Los Alamos proton radiography facility to validate the technique with modeling support from X Division. By allowing the spall layers to collide in "domino fashion" into an LiF window and observing the change in velocity of the metal/LiF interface, it is possible to partially infer the state and thicknesses of the spalled layers below the surface.

Mario and Rocco followed two confirmatory shots, Blue #1 and Blue #2, that were executed in 6-ft-diameter containment vessels in "G" drift of the U1a complex. These shots were identical to Mario and Rocco with the exception that the confirmatory shots used containment spheres and specially designed surrogate alloys instead of plutonium.

Rocco benefited from the lessons learned on the Mario event, and improvements were made to alignment methods in fielding Rocco. The improvements not only resulted in higher-quality line VISAR data but also saved time during setup and allowed an earlier execution of the Rocco event. ✸

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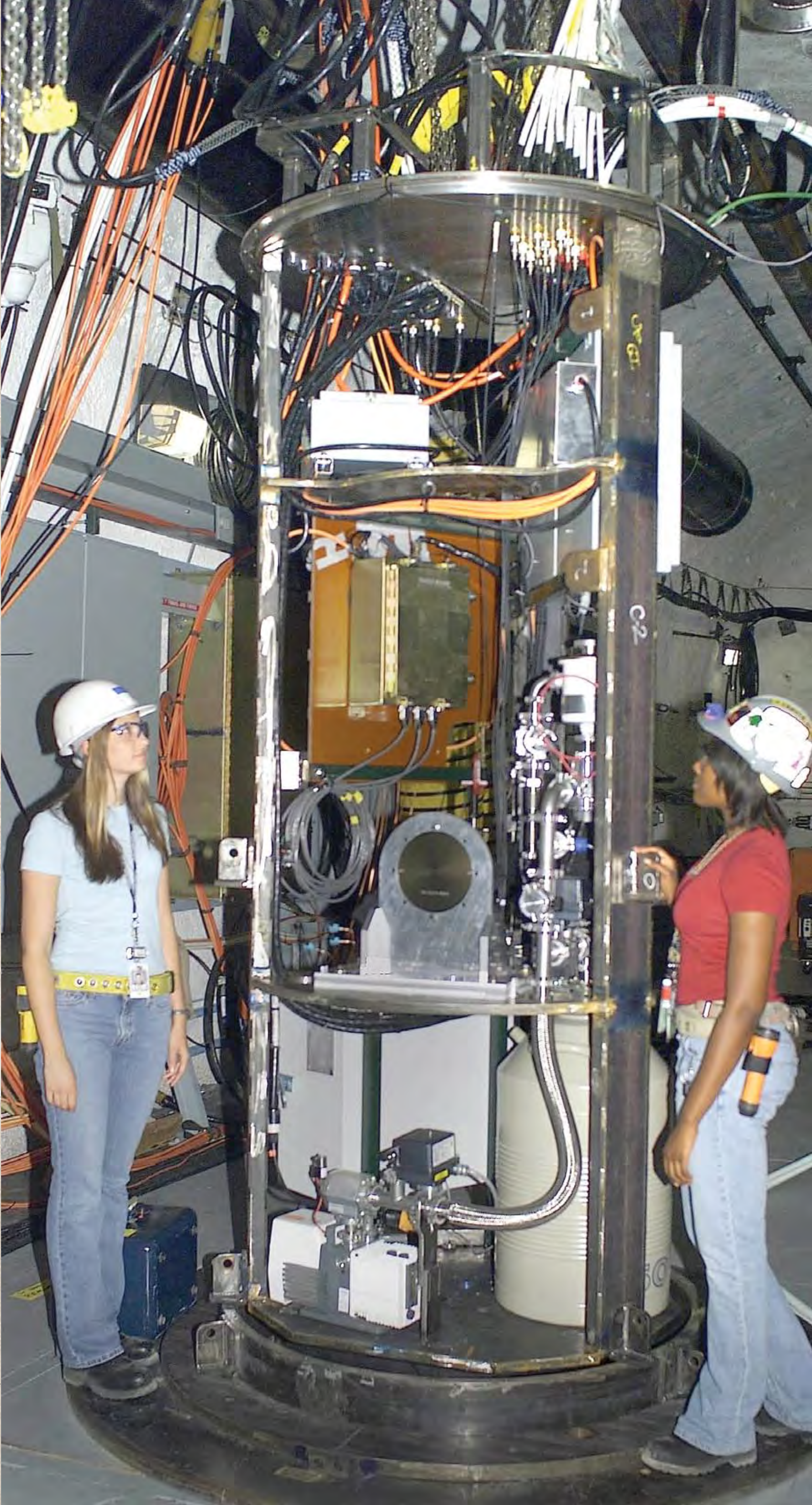

The assembled racklet for the Rocco SCE in the U1a complex at NTS. The racklet was lowered into the containment hole, and stemming and sealing materials were poured into the hole to fully contain the experiment.

John Flower

Fragment Impact Initiation of High Explosives

Any explosive-containing device may be expected to react (chemically) when impacted by fragments of appropriate size and velocity. Reaction violence spans a broad spectrum that ranges from a high-order detonation to mild gas production, resulting in minimal damage to the assembly.

Chemical reaction is caused by the generation of sufficiently elevated thermal states in the chemically metastable explosive. In fragment impact, arrival at such elevated thermal states is via mechanical processes. One such process is shock. It is generally accepted that shocks collapse pores in explosives, and the plastic work done during pore collapse generates the elevated thermal states that may lead to initiation, although impacts of low amplitude often do not initiate the explosive.

In fragment impact, many additional mechanical effects occur that may result in local deposition of thermal energy in the explosive. Many of these effects are due to the generation of shearing motion in the explosive material and are loosely referred to as shear initiation. However, shear alone is unlikely to initiate most explosives; rather; some compression must coexist with the shear.

Thus, the response of an explosive-containing device to fragment or bullet impact depends on a large number of parameters. Known parameters include device geometry, the geometry of the impacting fragment (e.g., length, width, thickness), the orientation of the impact, the mechanical and shock properties of the impacting fragment, the mechanical and shock properties of the explosive, the chemical and microscale properties of the explosive, and the mechanical and shock properties of each of the inert materials in the device. Further, the response will strongly depend on adverse initial conditions, such as preheating of the device in a fire.

Shock is the best understood initiation mechanism because it is fundamental when explosives are intentionally detonated (by detonators) and in detonation propagation. Rational models of shock initiation exist; mechanisms based on shear or a combination of compression and shear are less understood.

In pursuit of the long-term objective to adequately model the response of any explosive device to any stimulus, we are developing various experiments that allow characterization of the initiation mechanism and experiments to study the thermal and mechanical details of sheared explosive. The former experiments can be viewed as a variant of a classical bullet-impact test derived by the removal of the rear confining structure to allow optical access to the propagated wave, combined with impact point modifications that enhance the shearing action at the projectile periphery. The sheared explosive experiments are designed to generate an observable, localized region of shear while under compression.

In the modified bullet-impact tests, a projectile fired from a gun at a known velocity impacts the assembly and causes the explosive charge to respond. Observation of the wave characteristics on the rear surface of the explosive allows for some characterization or categorization of the mechanism involved. Prompt detonation results in catastrophic damage to the assembly, whereas partial or building detonations may result in relatively mild damage.

Results of experiments like those described here can be used to identify test conditions that merit further study. For instance, the "partial" deto-nation (c) shown on page 12 is repeatable and can be studied in more detail to yield additional model-validation data. Experimental data are often used in safety studies in the form of pure empirical correlations, which most often contain no physics. Great care must be exercised in their application. Achievement of our long-term goal will obviate the need for such correlations. ✸
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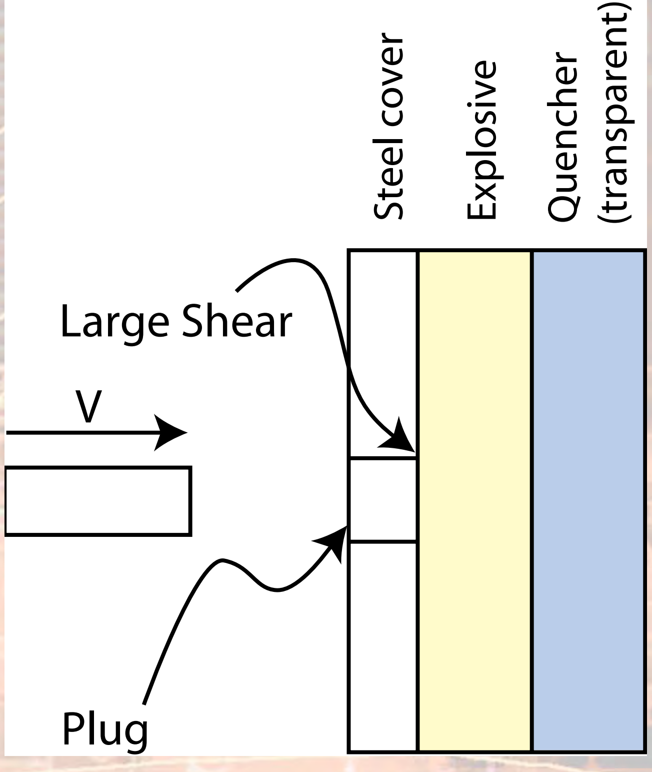
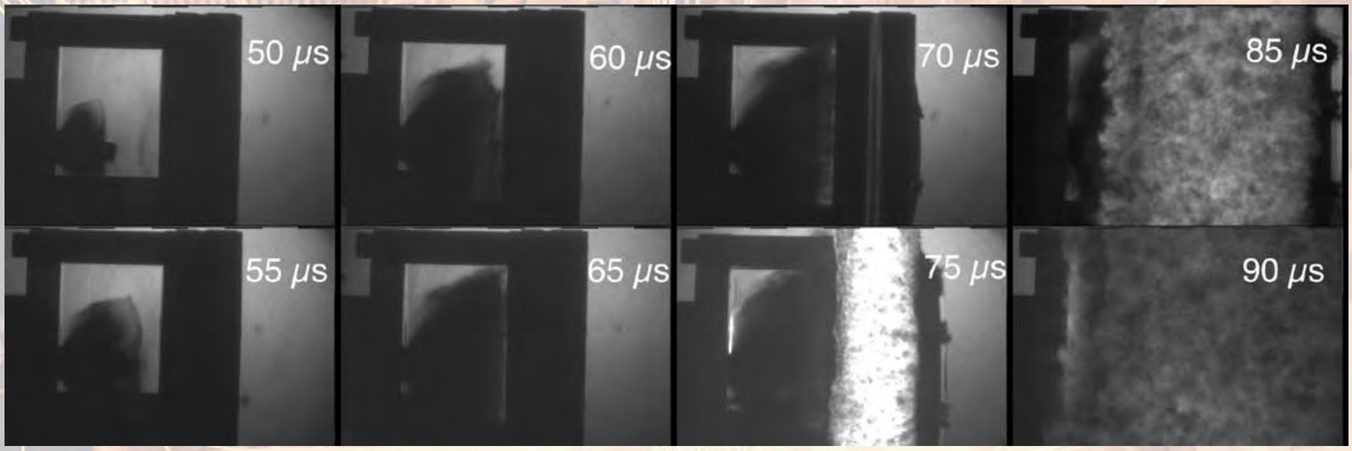
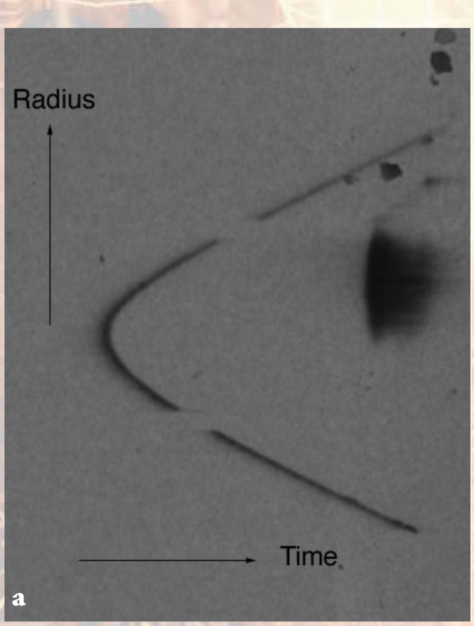


Schematic of the version of the bullet-impact test variant used in the modified bullet-impact tests.

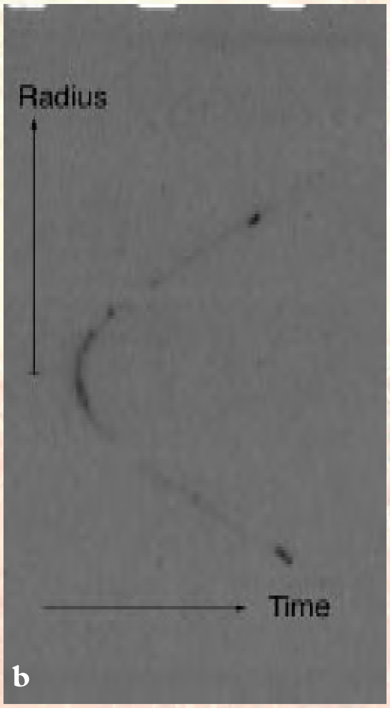
PBX-9501 damaged from the impact of a projectile fired at 430 m/s (low velocity).



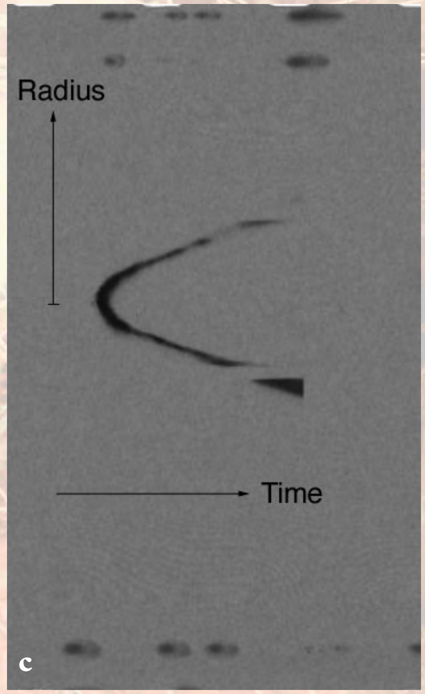
Framing camera data from an impact onto PBX-9501 at 1,610 m/s (high velocity). The early frames show the projectile before impact, and the later frames show the detonation of the explosive. The gas products from the gun-propellant burn overtake the projectile just prior to impact.



Streak-camera data from an impact onto PBX-9501 at 1,610 m/s.



Streak-camera captured arrival time characteristic for steady, high-order detonation in PBXN-110.



Streak-camera captured arrival time characteristic for "partial" detonation generated by an impact at 1,470 m/s.

The streak records provide the arrival time of the shock-wave at the rear surface of the explosive as a function of radius from the center of the charge. Shock-wave characteristics can differ significantly: note the differences in wave shape between the "partial" reaction in (c) and the detonations in (a) and (b)—the scales are all the same.

The Insider Threat: A Significant Challenge

The destruction of the World Trade Center towers created anxiety among Americans as to whether we can trust our neighbors. The November 17, 2002, *London Sunday Telegraph* talks about a video that shows hotel guests ordering from room service only to be assassinated when they open their door to whom they assume is the waiter. This article suggests that a terrorist could surreptitiously apply for a job in the hotel, be hired, and act as an insider in facilitating, contributing to, or committing a terrorist attack.

The insider threat is a concern for DOE and the national laboratories; DOE defines an insider as

> ***"Anyone who has authorized access—whether physical or electronic—to information and infrastructure resources. Insiders have always posed a threat. Some have been outright agents of an enemy government, and others have been disgruntled employees. Because insiders have authorized access, positions of trust, and first-hand knowledge, they can inflict particularly serious damage.***
>
> ***"This is truer today than ever before because our high-tech workplace gives insiders the advantage of enormous processing power and interconnected information systems. . . .***
>
> ***"An insider with malicious intent can cripple a closed system just as effectively and quickly as an external expert can cripple an open system. In fact, the insider's work might even be easier than the outsider's, given that the insider is usually under no particular suspicion and knows the system and its controls. No nation has ever been able to eliminate the insider threat."***

www.issm.doe.gov/GenInfo/FAQs.html

Hostile insiders usually have access to critical areas, and they use their knowledge of facility operations to exploit weaknesses in security and abuse their authority to handle material or monitor alarms. Insiders can cause damage when they act alone, in cooperation with other insiders, or in league with outsiders. To counteract the threat, LANL uses a two-component systems approach: entrant analyses and threat mitigation programs. The DOE is developing a third component—insider/outsider recruitment.

In entrant analyses, we collect data on all staff and visitors for every facility that houses special nuclear material. This analysis looks at agency or group affiliation, Human Reliability Program (HRP) status, and individual statistics (e.g., time in area in minutes, number of days, and number of visits). We compare expectations versus statistics and then compare statistics for HRP and non-HRP personnel. We conduct a statistical assessment on visitors' agency or group affiliations and an information path analysis, which looks at all possible paths and avenues that an insider might exploit. This analysis also allows us to assess trends that may be developing or unobtrusive measures that may be leading to an attack. Once we complete an entrant analysis, we mitigate any identified threat.

Threat mitigation programs use a systems approach to apply required upgrades where needed. At LANL, mitigation programs include security awareness briefings and training, access control systems, alarm response office and protective force, facility systems, materials accounting, surveillance and controls systems, material access areas, protected areas, and repositories and safes. These areas consist of overlapping mitigation-protection measures.

Back at the hotel, if a security director were to account for all hotel employees (insiders) and outsiders (guests, delivery people, terrorists, criminals, etc.); determine the risk of terrorist attack; and evaluate mitigation programs like hotel access systems, law enforcement or security alarm response, video surveillance, and employee and guest background checks, there would be a much higher probability that an insider terrorist would be identified and the assassination averted. In this type of insider analysis, we use data and trend analysis to assist in averting assassinations, to pinpoint disgruntled employees, and to discover possible links to their outside relationships.

The insider analysis program provides an overall facility risk assessment for the entire spectrum of insider threats. Several government and private organizations have come to recognize the rigor and formality of DOE's program and have requested training and assistance with their own analyses. ✹
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Planning *and* Integration Office

Integrating Management of the Nuclear Weapons Program

The Planning and Integration Office (PIO) was established last fall to support the planning activities of the Los Alamos Nuclear Weapons Program Integration Board (PIB) and its four coordination boards: the Stockpile Assessment and Response Coordination Board, the Simulation Capability Coordination Board, the Experimental Assessment and Validation Coordination Board, and the Manufacturing Coordination Board. Under this broad charter, the PIO supports the entire weapons program by tracking the integrated program and maintaining documentation of the program's scope, schedule, and budget. PIO does not make decisions but helps to develop informa-tion and to analyze the status of changes to scope, schedule, and budget (and their impacts).

> ***"The challenge is to make program planning and execution less onerous while strengthening the coherence among technical and program requirements, resource allocation, and program delivery."***
>
> ***—Ray Juzaitis***
> ***Decision Memo for the Thirty-Day Study***

The PIO focuses on developing the Laboratory's weapons program baseline, which includes technical planning and project management support for a defensible, integrated, and sustainable nuclear weapons stewardship program. The office provides decision support to the PIB and the coordination boards; coordinates resources to analyze existing and proposed work elements; and serves as liaison and works closely with the Enterprise Project (EP), NNSA NA-13, and the Planning, Programming, Budgeting and Execution System (PPBES) team led by Alex Gancarz (BUS-DO).

Office Director Craig Leasure, Curtis Thomson, and a small team that includes support from D-7 and PM-4 will staff the office and report to the Associate Director for Weapons Physics, who chairs the PIB. Working with leaders and managers in the program, the team will meet several milestones in FY03:

- Nuclear weapons baseline for FY03–09,
- Quarterly status reports for the weapons program (beginning April 2003),
- Change control policy and procedure for the weapons program (by March 31, 2003).

The three major elements of the PIO's mission are baseline planning and management support, decision support, and liaison activities.

Baseline planning and management support will require the PIO to coordinate the development and management of the nuclear weapons portion of the Laboratory's baseline. This work will be organized hierarchically, using an integrated program structure: program element managers (PEMs) submit plans to the coordination boards, the boards review and accept the plans and recommend approval by the PIB. The PIB forwards the plan to the Laboratory Director; once approved by the Director, this plan becomes the program's baseline. The PIO will produce summaries of the five-year program baseline, including the prior year's actual information, data for the current year, and projections for the next five years. Forecasting and budget activities that are part of the five-year plan will require the office to work closely with BUS Division personnel.

The PIO will provide planning tools to the coordination boards and PEMs, including a program-element-plan template, a work-package template, and out-year planning guidance and a template. Additional tools, analyses, and project-planning resources will be available to division leaders, PEMs, and project leaders.

PIO will support the change-control process with a tiered approach that will be implemented at all levels of the program. Personnel will be trained to function in a system in which baseline changes are assessed, tracked, managed, and documented. The PIO sets the baseline configuration each year and will manage the subsequent review change process. The baseline will be documented against requirements, and data will be validated to ensure that the system provides valid information.

Lastly, the PIO will develop, promulgate, and support quality- and configuration-management policies and procedures that will be applied to all information, documents, reports, and studies used by the PIB or the coordination boards to develop baselines and make decisions. The PIO will be the custodian of this material and will develop archiving practices to facilitate future access to the information.

Decision support is a set of activities comprising the near-term and tactical support of management of the nuclear weapons program. The PIO will develop quarterly status reports on the weapons program and provide analyses on alternatives and long-term impacts to decisions by working closely with D Division and other organizations.

The PIO will lead PIB meetings by identifying and negotiating an agenda, facilitating meetings, identifying and tracing action items, and providing alternatives analyses. Of particular interest is supporting deputy associate directors at the PIB meetings, where they make assignments and decisions regarding issues that cross the coordination boards, by collecting issues that transcend individual boards and forward these issues for analysis.

Liaison activities include communicating program requirements and direction to internal organizations in the weapons program and other Laboratory-wide programs, like PPBES and EP, and working with NNSA NA-13 to ensure open communication regarding processes and practices.

* * *

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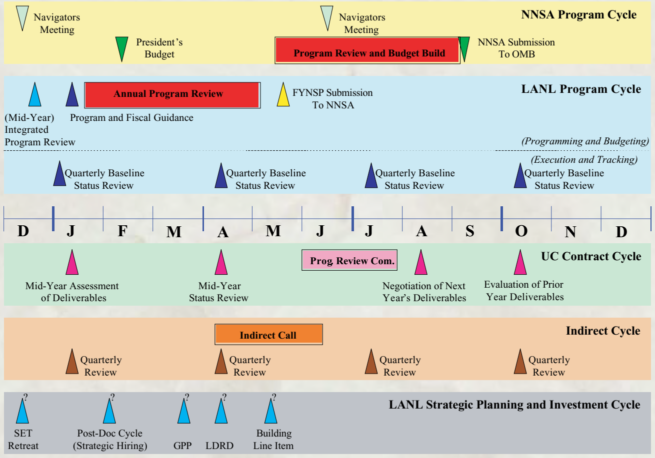
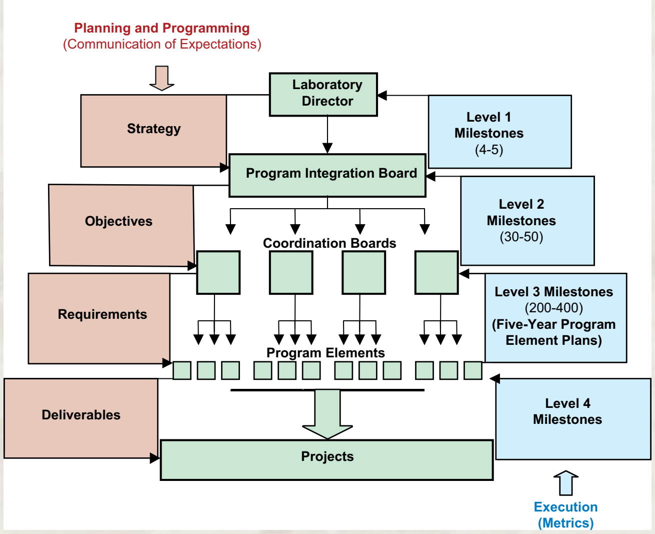


A primary focus of the PIO's work will be to maintain the program's strategic calendar and ensure that scheduled deliverables are met. This graphic demonstrates the many elements across NNSA, LANL, and UC calendars that the PIO will be tracking simultaneously.



The strategy developed by senior management establishes expectations and objectives for the weapons program. These expectations flow down to technical divisions, where the work is planned as deliverables; the plan is returned to management for review. The successful execution of the program plan is reflected in the completion of the milestones.

Point of View from page 1

that we face within TA-55 and those imposed on us by new environmental regulations. Drawing on many resources—including the Telluride Project, LLNL, and the UK—we developed new casting processes that require substantially less space, generate a fraction of the waste, and provide a much more uniform product than ever achieved before.

We developed machining and inspection techniques that have significantly pushed the state of the art and deployed joining technologies that provide greater control and a more consistent product. Our assembly team continues to put the various components together by hand, just as every pit in the stockpile has been assembled. This may seem like a strange practice in such a high-technology environment, but no machine can match the skill and touch of these artists who literally walk into a room and put the plutonium components together with their hands.

Our people have risen to the challenge and are in the home stretch of delivering Qual-1. This effort required the dedication and support of many organizations across the Laboratory. I want to thank those whose work has been impacted for your patience while we dedicated resources to this critical activity. Most importantly, I want to thank all of you who have worked so hard to get us to this point.

It has been a long, hard journey, and we are now well-poised to provide the Laboratory with a tremendous success that is being closely monitored by NNSA, DoD, and Congress.

Thank you for your hard work and dedication. ✹

D	Decision Applications Division
DARHT	Dual-Axis Radiographic Hydrodynamic Test
DoD	US Department of Defense
DOE	US Department of Energy
DX	Dynamic Experimentation Division
EP	Enterprise Project
FDI	frequency domain interferometry
HE	high explosives
HERCULES	High Explosives Reaction Chemistry via Ultrafast Laser Excited Spectroscopies
HRP	Human Reliability Program
LANL	Los Alamos National Laboratory
LLNL	Lawrence Livermore National Laboratory
MIT	Massachusetts Institute of Technology
NNSA	National Nuclear Security Administration
NTS	Nevada Test Site
NWJ	Nuclear Weapons Journal
P	Physics Division
PEM	program element manager
PIB	Program Integration Board
PIO	Planning and Integration Office
PMMA	polymethylmethacrylate
PPBES	Planning, Programming, Budgeting and Execution System
SCE	subcritical experiment
SNL	Sandia National Laboratories
UC	University of California
UK	United Kingdom
VISAR	velocity interferometer system for any reflector
X	Applied Physics Division

A Backward Glance

Los Alamos, 1943: Ivory Tower or Frontier Boomtown?

Sixty years ago, J. Robert Oppenheimer spent three months traveling around the country, recruiting a first-rate staff for the newest and most remote science and research site of the Manhattan Engineer District: Los Alamos.

Considering the ongoing war, the remoteness of the undeveloped site, and the uncertainty over whether Los Alamos would be a military or civilian operation, Oppenheimer was remarkably successful in luring men from the nation's most prestigious (and comfortable) academic centers that included MIT, Princeton, Columbia, the University of Chicago, Stanford, Purdue, Johns Hopkins, and the University of California. He convinced them to come to a wind-and-dust frontier on the edge of nowhere—literally on the brim of Pajarito Plateau.

The first order of business was turning this nearly inaccessible and sparsely populated mesa top into a habitable space. One immediate issue was potable water; the area had been in a severe drought for years, resulting in a grand-scale loss of piñons and junipers throughout the Southwest and a changed agricultural landscape in northern New Mexico. Other major problems included securing a dependable supply of electricity and phone service. Because of the secret nature of the project, this isolation was an asset.

In early 1943 there was no onsite housing, so most new recruits and their families lived on project-run ranches near Santa Fe and commuted to Los Alamos. Temporary onsite facilities, usually consisting of trailers and barracks housing that were surrounded by late-winter mud, did not become available until April. The commute was especially arduous because of the winter weather, poor road conditions, and the scarcity of good cars (domestic production had ceased 1943–45 because of the war).

Getting the staff here was one thing; delivering machinery and equipment here was quite another. Truck caravans loaded with equipment made the slow, 30-mile trek from the Santa Fe railway station to the base of Pajarito Plateau and inched up 1,700 feet via the one-lane, rutted, winding dirt road. Even the Cockcroft-Walton accelerator and the huge cyclotron borrowed from Harvard made this anachronous journey because the "Chili Line" railroad that had run north from Santa Fe had been dismantled in 1941, just a few years before the caravans started for Los Alamos.

Despite the primitive facilities, early staffers faced life in Los Alamos with a combination of enthusiasm and idealism because the important work of the Manhattan Project had begun. ✱

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